ELECTROSLEEP AND SLEEP PATTERNS

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To my wife, Sharon.

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CHAPTER 1

INTRODUCTION

In recent years there has been a reawakening of interest in various techniques to induce sleep (or otherwise alter consciousness) in man by means of externally applied electrical currents. The states so induced have been variously referred to as electrosleep, electroanesthesia, and electronarcosis. The three terms form something of a continuum in terms of the intensity of the currents employed. Electrosleep has been described by H. L. Williams (1963) as "a state of consciousness grossly indistinguishable from ordinary sleep, produced by the direct action of a weak rhythmic current on the brain of a cooperative subject in a nondistracting environment." Electronarcosis, on the other hand, Williams refers to as "a forced state of motor and sensory blockage, usually with loss of consciousness, produced by the direct action of a moderately strong current on the brain," while electroanesthesia is described as "a forced state of total anesthesia, with or without total loss of consciousness and paralysis produced by the direct action of a still stronger current on the brain." It is with electrosleep that this present work deals. It is said to be a voluntary state either identical to, or much like natural sleep (Gilyarovskiy, Liventsev, Segal, and Kirilova, 1958).

Various devices for the induction of electrosleep are being manufactured and sold in the United States. Claims have been made regarding the therapeutic potential of these machines with respect to an amazing number of functional and organic pathological conditions (Forster, Post, and Benton, 1963; Roitenburd, 1965). It is not, however, the purpose of the present work to evaluate in any way the therapeutic potential of the technique, but only to investigate the nature of the sleep which is said to be induced thereby. This has been done by a comparison of EEG data taken from a group of subjects to whom, in a conventional manner, the rhythmic currents were applied, and to data taken from a control group. This comparison was made in terms of patterns of sleep over a period of time. Webb (1967) has pointed out that with respect tothe various stages of sleep, as scored by the system of Dement and Kleitman (1957), there is a marked intrasubject consistency across nights. These patterns can, of course, be temporarily altered by such potent agents as barbiturates and other pharmaceuticals. One can be led to expect then that subjects treated by electrosleep techniques might show alterations in sleep patterns which would not be found in subjects otherwise treated. Little parametric work has been done to determine the quality of sleep following the application of electrosleep currents. No electrosleep investigator has systematically studied post-application records in terms of sleep stages. The experiment reported in the following pages provides this data. Before a detailed description of the methodology of the present work a review of the background of electrosleep seems appropriate.

CHAPTER II

BACKGROUND

The investigation of electricity as a therapeutic agent seems historically to be nearly as old as the investigation of electricity as a physical phenomenon. It is said (Knoll, 1966) that Benjamin Franklin as early as 1750, using himself as a subject, tried Leyden jar shock from which he experienced a loss of consciousness and found the process to be "of some modest and transient therapeutic value in palsy" (p. 2). Van Poznak (1963) in his review cites the work of Mach in 1875 as the beginning of electronarcosis. Mach succeeded in immobilizing fish when he passed a direct current between electrodes immersed in their water. In 1902 Leduc is said to have produced sleep and general anesthesia in rabbits by means of a transcerebral application of an interrupted low intensity current (Forster, *et al.*, 1963). Later that same year Leduc attempted a similar experiment upon himself using a pulsed current of 3-12 milliamps of direct current. He did not lose consciousness but claimed to have lost voluntary movement and to have experienced feelings of fear and helplessness (Van Poznak, 1963, p. 102).

By 1914 Rabinovitch had introduced the term "electric sleep" which she distinguished from analgesia or electroanesthesia. She describes the process as one in which a negative electrode was placed on the forehead with the positive electrode on the palm of her hand.

The current was gradually stepped up to 3/4 of a milliamp of direct current and her patients were reported to have gone to sleep within a few minutes and to have awakened feeling refreshed after more than an hour (Rabinovitch, 1914). The research in this area from 1914 until 1953 was essentially a matter of trying various combinations of current parameters with both man and animals and is thoroughly reviewed by Van Poznak (1963), Austen (1965) and Lewis (1966). Both alternating and direct currents were used by a number of investigators. Direct currents were applied both constant and pulsed with a wide variety of wave forms, amperages, and voltages (see Lewis, 1966, pp. 52 and 53 for a comprehensive table of these parameters).

The real impetus for electrosleep research as it is seen today stems from the theoretical and experimental work of Pavlov. In his study of the physiology of sleep Pavlov (1947) ascribed much significance to the effect of prolonged monotonous stimuli. He says that "foreign stimuli which may be repeated without further consequence for the animal also through their own effects alone lead to the development of an inhibitory condition in the cortex" (p. 59). In the same work he says: "Prolonged stimulation of the same points in the cortex leads to a very profound inhibition of them, which, naturally, by irradiating vigorously, encompasses the cerebral hemispheres and descends to the lower brain centers" (p. 221). Again in the same work he says: "Further, it is generally known that weak and monotonous stimuli make people sluggish, sleepy, and some actually fall asleep" (p. 327).

Gilyarovskiy and his associates (1958) offer the Pavlovian concept of protective inhibition as the rationale for sleep therapy. Lewis (1966) sums up their position as follows: "When faced with exhausting overstimulation, the organism can react with hindrance; this can exist in a single cell or radiate over the entire brain. In its fullest state, hindrance is seen as natural sleep; less complete degrees are expressed as various forms of hypnosis, sleepiness, or in some patients as symptoms such as catatonia, autism, and withdrawal. By adding a full and healing degree of hindrance, sleep is therapeutic" (p. 45).

Since drug-induced sleep often results in some unpleasant side effects, Gilyarovskiy and his associates (1958) looked for another means of promoting this protective inhibition or hindrance. They hypothesized that weak, low-frequency pulsed currents might produce a more natural sleep-like state. A pulse generator was built which could emit a mean current strength of 6-12 microamps and a pulse duration of .2-.3 milliseconds. Subjects reclined in a dimly lit room and electrodes in the form of silver discs covered with saline-soaked gauze were applied to the eyelids and mastoid areas. The cathode terminal of the generator was connected to the eyes. With a model pulse setting of 16 pulses per second and a gradual introduction of the current, the subjects experienced a vibrating sensation at the base of the skull and gradually began to feel lethargic. The current was gradually increased until the subject reported discomfort and then decreased slightly. Of over 1000 subjects, 337 were said to have slept during and after treatment. Electroencephalographic recordings were said to be inconsistent but to show an increase in both slow and high frequency activity.

A very extensive review of the American literature shows that nearly all recent experimentation with electrosleep has employed equipment and techniques similar to those just described. Burton Austen (1965) has used this fact to apply greater precision to the definition of electrosleep when he stated that "electrosleep can be defined not only as Williams has done, in terms of the type of state 'produced by the direct action of a weak rhythmic current on the brain,' but also in terms of the range of the stimulus parameters applied and the techniques used. Williams' definition could be extended by the insertion of '. . . produced by the application of rectangular pulses of less than 0.5 msec. duration, of less than 100 microamps. mean pulse strength, at a frequency of 1 to 30 pps., through electrodes placed over the closed eyelids (cathode) and mastoid process (anode) of a cooperative subject in a non-distracting environment'" (p. 6).

As cited above, Williams referred to electrosleep as a state grossly indistinguishable from sleep. Pavlov's remarks as interpreted by his contemporary followers (Gilyarovskiy, et al., 1958) indicate that a state of "natural" sleep should result from the application of the currents recommended. Very little, however, has been written which describes the qualitative aspects of sleep which is said to result. The report of EEG data by Gilyarovskiy and his associates (1958), i. e., that both high frequency and low frequency waves were seen in some cases to increase after treatment, are virtually uninterpretable in terms of modern techniques for the study of sleep.

The data available thus far has failed to establish a clear cut causal relationship between the applications of the currents and the sleep which may or may not follow. As has previously been mentioned, only about one-third of the cases reported by Gilyarovskiy actually slept during and after treatment. In the first American study of the same technique, Forster, et al. (1963) found that roughly half of the subjects exposed to the currents slept during or after the treatment. Straus, Elkind, and Bodian (1964) compared electrosleep treatments, sham electrosleep treatments, and treatments with 100 milligrams of phenobarbital. His subjects were nonpsychiatric in-patients who complained of difficulty in sleeping. The sleep of the three groups was compared on the basis of ratings by nurses and the patients themselves. No significant difference was noted between barbiturate sleep and electrosleep. The sham procedure was rated as inferior by the nurses but not by the patients. EEGs were taken before and after electrosleep treatments for four subjects and "no changes following the treatments were observed" (p. 518). It should be pointed out that, regardless of any hypothesized inhibitory effects which might be ascribed to the cerebral application of electrical pulses, the subjects of all these studies were reclining in a "nondistracting" environment with their eyes closed and might logically be expected to fall asleep. Moreover, Pavlov (1947), Oswald (1962), Kleitman (1963) and many others have spoken at length regarding the sleep inducing potential of various forms of monotonous and repeated stimulations. Kleitman (1963) goes on to point out that even the presence of monotonous stimuli is not essential to sleep induction as long as the subject relaxes and is somewhat confined with regard to movement capacity (as is the subject who is prepared for EEG or electrosleep). He cites the work of Lovell and Morgan (1942) in which control subjects showed as much tendency to become drowsy and fall asleep as did the experimental group who were subjected to a repeated tone. Lewis (1966) said: "Indeed, it seems a little surprising in the electrosleep studies that people repeatedly put to bed in a dim, quiet room with their eyes covered do not go to sleep more than 50% of the time, especially after the initial novelty wears off" (p. 55).

Electrosleep enthusiasts (Gilyarovskiy, et al., 1958; Clark and Webb, 1963; Lafayette, 1964) have strongly emphasized the importance of the application of the electrosleep currents to the head of the subject, usually in the precise manner described in the definition of Austen (1965) as previously quoted in this work. Gilyarovskiy (1958) states that "when the electrodes are arranged transcerebrally or oculo-occipitally the current enters the skull through the orbital fissure and the foramina in the orbits as well as through the thinner bones forming the walls and base; it leaves through the foramen magnum and thin cellular bones of the mastoid process. This is the best method of bringing the current into the skull and of making it penetrate into the brain substance" (p. 24). He goes on to say that if in place of the mastoid electrodes "an occipital electrode is used beneath the hairy part of the head, a considerable portion of the current branches off and passes through the soft tissues surrounding the skull " (p. 24). Certainly we could conclude from this that in Gilyarovskiy's opinion any sleep which might follow repeated electrical stimulation (within the ranges of the electrical parameters of his technique) of a fleshy part of the body far removed from the head would not be regarded as electrosleep. Partly for this reason pulsed electrical stimulation of the leg was applied to the control group in the present work.

It is apparent from many sources (Gilyarovskiy, et al., 1958; Andreev, 1960; Lewis, 1966) that a certain element of suggestibility enters into the usual electrosleep procedure. The technique is often explained to the subject as a procedure which will relax him and make it possible for him to achieve a beneficial form of sleep. So far, no double blind analyses of the procedure have been made which would compare electrosleep with any control technique. In concluding his review of the literature, Lewis (1966) states that until such research is performed "we cannot even be sure that electrosleep exists independent of the effects of suggestion and monotony, let alone evaluate its use in human disease" (pp. 55-56). Analysis of the sleep patterns of subjects to whom electrosleep currents are applied may provide a step in that direction. Two groups were used in the present study so that electrosleep (induced sleep) might be compared to sleep accompanied by stimulation in a manner not purported to induce sleep. The essential role of cranial application as quoted from Gilyarovskiy, et al. (1958) clearly implies that the effects of the two treatments should differ.

CHAPTER III

METHODOLOGY

Design of the Study

There were two conditions in this study. One-half of the subjects (the experimental group) received the standard cranial application of electrosleep current as detailed below. The other half of the subjects (the control group) received essentially the same current applied to a leg. The two groups were compared in terms of their deviations from a previously established baseline session in which no current was used.

Procedure

There were five consecutive experimental days for each subject. Subjects were studied in pairs in the psychophysiology laboratory of the J. Hillis Miller Health Center which has EEG facilities for the simultaneous recording of the sleep records of two persons sleeping in separate rooms. These rooms are essentially identical. Each contains a comfortable bed and is carefully controlled to prevent variations in lighting, temperature, and sound. In a central control room are located two twelve-channel EEG machines and, during the course of the present research, one two-channel pulse generator (electrosleep machine or ESM). From the control room the experimenter can communicate with or monitor the subjects in the sleeping rooms by means of intercom systems. The experimenter and subject can also communicate by means of a push-button operated tone generator.

The ESM was constructed by the electronics staff of the J. Hillis Miller Health Center. The device is capable of generating unidirectional current pulses at 20 pulses per second with a mean current strength which could be varied from 0 to 20 microamps. The pulse duration was set internally at .3 millisecond. These are essentially the same parameters employed by Forster, *et al*. (1963) as interpreted by Austen (1965). The ESM used in the present study is, however, constructed so as to accommodate two subjects simultaneously with a fixed pulse rate and independently variable rates of amperage. Current strength is set for either channel by means of external dials and can be monitored continuously by two conventional microammeters on the face of the device (see Figure 1 for a photograph of the ESM). Two cables lead from the ESM to the sleeping rooms. In the rooms the cables terminate into two wires. Each of the wires, in turn, terminate into a Y-shaped yoke with two disc-shaped silver electrodes 3/4 inch in diameter. Thus, there are four electrodes in the room for each patient. The two cathode electrodes are slightly indented to fit comfortably against the eyelids while the anode electrodes are flat and fit against the mastoid area. When applied to the subject the eye electrodes were heavily smeared with electrode jelly and taped securely to the eyelid which had been taped shut. The mastoid leads were secured with colodion saturated gauze

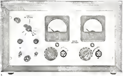

Fig. 1.—The Pulse Generator or Electrosleep Machine.

pads and were also smeared with electrode jelly to enhance current flow and to prevent dryness and heat.

The subjects were prepared for the EEG as follows: The International 10-20 System was used for electrode placement at the following sites: F_1, F_2, F_7, F_8, C_1, C_2, C_5, C_6, P_1, P_2, T_5, T_6, O_3, O_4, and O_zP_z. Grass silver disc electrodes were applied using a mixture of bentonite and cambridge electrode jelly. Two additional electrodes were used to record the EOG, one placed supra-orbitally on the right side, the other infra-orbitally on the left. All electrodes were secured with colodian saturated gauze pads.

Ten channels of the twelve-channel Grass EEG machines were used (8 for EEG and 2 for EOG). The electrodes were referred as as follows: F_1 to F_7, F_2 to F_8, C_1 to C_5, C_2 to C_6, P_1 to T_5, P_2 to T_6, O_3 to O_zP_z, O_4 to O_zP_z, left infra-orbital to right supra-orbital, and left infra-orbital to F_7. The two additional channels were carried in reserve in case of malfunction. The paper speed was 15 mm/sec.

The subjects were twelve male students at the University of Florida and ranged in age from 18 to 25 (mean 21.1 years). Each was a volunteer and was paid $1.00 for each hour spent in the laboratory. Because of some precautionary remarks by Gilyarovskiy, et al. (1958) regarding the possible danger of ablatio retinae in electrosleep treatments, all subjects were given a funduscopic examination by a staff physician. None were rejected on this basis. One subject was rejected before his first trial when it became apparent to the experimenter that he had read about electrosleep and suspected that the study involved its use. For the purpose of controlling for suggestibility effects the experimenter told none of the subjects the purpose of the experiment. On the basis of their initial (baseline) sleep latencies subjects were assigned to balanced groups. The student health service was consulted to make certain that none of the volunteers had ever applied for psychotherapy or any psychiatric care. One volunteer was found to have been a psychiatric patient and rejected.

Each pair of subjects was run for five consecutive (Sunday through Thursday) days for periods of approximately two hours each. The first of each pair reported to the laboratory at 12:30 P.M. and was prepared for the experiment. The second reported about one hour later and underwent the same procedure while the first lay in the sleeping room. Noting some small but significant differences between early and late naps with regard to distribution of stages reported by Maron, Rechtschaffen, and Wolpert (1964), the experimenter assigned three control subjects and three experimental subjects to each starting time.

To each subject the EEG electrodes were applied first. Then he was given an opportunity to go to the restroom and prepare himself for bed. He was then taken to the sleeping room where his eyelids were taped shut and the ESM electrodes were applied. So that the comfort of both experimental and control subjects would be similar every subject had ESM electrodes applied to both the head and leg. Subjects in the experimental groups wore "dummy" electrodes on the leg while the control group wore "dummy" electrodes at the eyes and mastoid area. On the first or baseline night no ESM current was used. Each subject was told that he was to lie in the room for about two hours and that he would be notified when his time was up. He was further told that he could sleep if he chose but that it was not essential that he do so. The examiner turned off the lights and left the room closing the heavy doors behind him. The subject was advised by means of the intercom that should he need anything he could be heard by the experimenter. The EEG was then calibrated and left running for two hours after which the subject was notified by means of the intercom that his time was up, led from the sleeping room and had the various electrodes removed.

If at any time during the experimental procedure a subject asked the purpose of the study he was told that the experimenter was simply interested in the electroencephalographic characteristics of young adults. If questions were asked regarding the purpose of the ESM electrodes, the subject was told that these served to amplify the EEG readings.

On the second and subsequent experimental days there were two added procedures. After the subject was put to bed a microswitch was taped to his preferred hand. Before starting the EEG recording the experimenter asked the subject by means of the intercom to listen for a tone and to signal when he heard it by pressing the microswitch. The experimenter then pressed a button which activated a tone generator which was linked to a speaker in the sleeping room.

The sound heard by the subjects was 1000 cps. at 40 db. and .50 second in duration. The subject's microswitch response activated a pen on one of the unused channels of the EEG to signal the experimenter.

Having acquainted the subject with the signalling procedures the experimenter turned on the ESM. The current strength dial was initially set at 0 while the machine warmed up and the subject was informed that he might soon feel a mild tingling sensation (at the eyes and behind the ears if an experimental subject, or at the leg electrodes if a control subject) and he was asked to tell the experimenter when he first felt it. The current was gradually introduced until the subject reported the sensation of its presence. At this point the experimenter recorded the reading of the microammeter. The subject was then instructed to tell the experimenter if and when the intensity of the tingling became uncomfortable or annoying and the current was slowly increased until either the subject reported discomfort or a meter reading of 20 microamps was reached. The current was never increased beyond 20 microamps in that this was the maximum reliable reading of which the meters were capable. If this level was reached without a report of a discomfort by the subject, the setting remained unchanged for the hour during which the current was applied to the subject. If at any point the subject reported discomfort he was informed that the current was being reduced slowly and he was asked to report when it became comfortable again. The experimenter waited for thirty seconds to see if the subject would adapt to the current and report it as comfortable. If no such report was forthcoming the current was slowly reduced until the subject responded, at which point the setting was maintained for one hour (see Table 1 for the settings used).

On the second and subsequent trials, no continuous EEG recordings could be made during the first hour due to the electrical interference of the ESM. Intermittent recordings were accomplished in the following manner. Ten minutes after the final ESM setting was achieved, the experimenter sounded the signal tone. This tone was repeated at random intervals. The mean of these intervals was five minutes. If at any time the subject failed to respond to two consecutive signals the ESM was turned off and a 60-second EEG recording was taken. After such a recording, the ESM currents were resumed. Subsequent intermittent recordings were made in the same manner every ten minutes until the ESM current had been applied (at its final setting) to the subject for one hour. At the end of this hour, the ESM was turned off and a continuous EEG recording was initiated. The length of the continuous recording was determined as follows: At the time of the subject's second failure to respond to the signal, he was assumed to be asleep. This time was recorded and the subject was awakened two hours thereafter at which time EEG recording was ceased. In the event that no two consecutive response failures occurred during the first hour, the ESM was turned off and a two-hour EEG recording was taken.

The records were scored by a skilled technician employed by the laboratory. The scorer was not aware of the identity of the

TABLE 1

CURRENT STRENGTHS IN MICROAMPERES
(Threshold, Discomfort and Final)

Subjects	Days											
	2			3			4			5		
	Thr.	Dis.	Fin.	Thr.	Dis.	Fin.	Thr.	Dis.	Fin.	Thr.	Dis.	Fin.
Experimental Group												
1	10	16	12	12	20	16	5	8	5	5	18	14
2	12	18	15	12	19	15	6	10	8	3	6	5
3	9	14	11	10	17	13	8	11	9	5	15	12
4	10	12	12	9	14	12	9	12	11	8	13	12
5	6	8	7	5	10	6	8	11	10	6	14	13
6	6	14	10	9	20	16	12	18	14	8	20	18
Sum	53	82	67	57	100	78	48	70	58	35	86	74
Mean	8.83	13.67	11.17	9.50	16.67	13.00	8.00	11.67	9.67	5.83	14.33	12.33
Control Group												
7	8	15	10	3	4	3	3	5	4	7	8	8
8	8	15	12	8	16	10	7	16	11	10	18	16
9	9	14	13	8	15	13	8	13	9	13	16	15
10	10	20	15	5	20	16	8	20	19	12	20	20
11	10	20	18	10	20	18	12	15	13	18	20	18
12	4	5	4	4	8	7	5	6	6	7	12	10
Sum	49	89	72	38	83	67	43	75	62	67	94	89
Mean	8.17	14.83	12.00	6.33	13.83	11.17	7.17	12.50	10.33	11.17	15.67	14.50

subjects or of their group assignments. The records were scored using a modified version of the method suggested by Dement and Kleitman (1957). This modification which has been in use for some time at the University of Florida, is fully described by Williams, Agnew, and Webb (1964). After scoring, the records were analyzed in terms of sleep Stages I-IV which are characterized by Webb (1967) as a depth of sleep continuum and State I-REM which is associated with visual dreaming. Analyses can be made in terms of latency, length, order, and frequency of occurrence of the various stages.

CHAPTER IV

RESULTS

Comparison of the Nonexperimental Sleep of the Subjects to that of Other Young Adults

During the first session (baseline day) a two hour continuous record was taken for each subject and scored for sleep stages. This was done to obtain estimates of the "normal" or nontreatment sleep of the subjects. In order to determine whether or not the subjects in this study differed from other young adult males in their sleep patterns this data was compared to that of Webb and Agnew (1967). The authors just cited studied a group of 12 young adult males (ages 17-21 years) whose sleep sessions began at 12:30 P.M. In the present study, six subjects began their sessions at 1:15 P.M. (with slight variations depending on wiring time) while the other six began at approximately 2:15 P.M. From Table 2 it can be seen that the baseline sleep of the 12 subjects in the present experiment differs very little in terms of stage distribution from that of the subjects of Webb and Agnew (1967). The greatest difference between the two groups is in mean percentage of Stage II (3.66 per cent) and is really quite small considering that both groups spent upwards of 40 per cent of their total time in this stage. Both the data of Webb and Agnew and that of the present author can be further compared to that of Maron et al. (1964) who reported that their 12 young adult

TABLE 2

MEAN PER CENT OF TIME SPENT IN EACH STAGE OF SLEEP COMPARING THE DATA OF WEBB AND AGNEW (1967) AND THE BASELINE NAPS OF ALL 12 SUBJECTS IN THIS STUDY

Stage	Webb and Agnew Per cent	Present Study Per cent
0	10.79	9.04
I	13.76	11.26
I-REM	11.85	13.56
II	44.37	40.69
III	4.34	7.33
IV	14.89	18.08

subjects (reported to be "in their 20's or early 30's," p. 504) during afternoon naps averaged 14.6 per cent of Stage I-REM (compared to 11.85 per cent for Webb and Agnew's subjects and 13.56 per cent for the subjects in the present study). Maron et al. further report a combined percentage for Stages III and IV of 19.3 per cent (compared to 19.23 per cent for Webb and Agnew and 25.41 per cent for the present author). Thus it would appear that the data for all three sets of young university students is quite similar and that the subjects in the present study are not unusual with regard to their afternoon sleep patterns.

Sleep Samples During Electrical Stimulation

It will be recalled that during the actual current application (electrical stimulation during the entire first hour of each experimental session) so continuous EEG recordings could be made. In order to obtain some estimate of the quality of sleep during the first hour of these sessions (days 2-5) it was necessary to take samples in the form of brief EEG records at intervals determined by the procedure described in the preceding chapter. The number of such samples is determined for any given subject on any given experimental day by sleep latency. If a subject reached Stage II (as determined by his second consecutive failure to respond to a signal tone) quickly during current application there would be an opportunity for a greater number of sample recordings than if he had taken a longer time to fall asleep. Since the first signal tone was always sounded 10 minutes after the beginning of the session and since the second tone followed approximately 5 minutes later, the shortest possible sleep latency by this criterion would be approximately 15 minutes. Since subsequent sample recordings were made at randomized intervals, the mean of which was 10 minutes, a subject with the minimum latency on a given night would yield 5 sample recordings. A subject with a sleep latency of 20 minutes would yield 4 samples and a subject with a latency of 50 or 55 minutes would yield only one.

Referring to Table 3 it can be seen from the column sums that the experimental group had a greater number of sample recordings than the control group in every experimental session but the last (each group had 16 recordings in the fourth experimental session). The number ofsuch recordings is, of course, determined by latency, i.e., the shorter the latency of sleep onset, the

TABLE 3

NUMBER OF SAMPLE RECORDINGS DURING THE FIRST HOUR OF EACH EXPERIMENTAL SESSION FOR EACH STAGE ACROSS THE FOUR EXPERIMENTAL SESSIONS

Stage	Days				Sum	Per Cent
	2	3	4	5		
Control Group						
0*	2	0	0	0	2	3.03
I	1	2	2	1	6	9.09
II	6	8	9	5	28	42.42
III	0	2	3	1	6	9.09
IV	4	5	6	8	23	34.84
I-REM	0	0	0	1	1	1.51
Sum	13	17	20	16	66	
Experimental Group						
0*	1	3	4	1	9	11.11
I	1	2	1	0	4	4.93
II	10	7	6	9	32	39.50
III	3	5	5	4	17	20.98
IV	3	6	7	2	18	22.22
I-REM	0	1	0	0	1	1.23
Sum	18	24	23	16	81	

*Stage 0, as used here and elsewhere in the text, refers to periods of wakefulness which occur after sleep onset.

greater the number of sample recordings. A more direct measure of latency is simply the time of the first sample recording or, if there are no samples, the time of the first minute of Stage II in the subsequent continuous recording. For the baseline session the measure of latency is always determined by the first minute of Stage II. Table 4 shows the latencies for each subject across all five days. From the group means it can be seen that the experimental group

TABLE 4*

SLEEP LATENCIES FOR BOTH GROUPS ACROSS DAYS AS DETERMINED BY ONSET OF FIRST STAGE II OR SECOND FAILURE TO RESPOND TO SIGNAL

Subject	Days				
	Baseline	2	3	4	5
Experimental Group					
1	29	35	15	35	30
2	28	40	30	30	30
3	60	40	40	30	30
4	7	35	15	15	40
5	12	20	15	15	61
6	7	20	20	20	15
Sum	143	190	135	145	206
Mean	23.83	31.67	22.50	24.17	34.33
Control Group					
7	36	70	20	30	20
8	25	25	25	20	20
9	9	50	64	15	25
10	1	45	61	30	60
11	4	30	20	20	25
12	20	30	15	15	64
Sum	95	250	205	130	214
Mean	15.83	41.67	34.17	21.67	35.67

*Time in minutes.

TABLE 5

SUMMARY ANALYSIS OF VARIANCE FOR SLEEP LATENCY CONTRASTING TWO GROUPS IN TERMS OF CHANGE SCORES FROM THE BASELINE SESSION ACROSS THE FOUR EXPERIMENTAL SESSIONS

Source	SS	df	MS	F
Between - Subjects	14679.73	11	1334.52	
Groups	2067.19	1	2067.19	1.64
Error (b)	12612.54	10		
Within - Subjects	8026.75	36	222.97	
Days	1443.23	3	481.08	5.43*
Days x Groups	3927.65	3	1309.22	14.79**
Error (w)	2655.87	30		
Total	22706.48	47		

*Significant at .01

**Significant at .001

has a somewhat longer latency for the baseline session and shorter latencies for all but one of the experimental sessions (day 5). A t-test for the baseline differences shows that the groups were not significantly different at the .05 level on that day.

A Lindquist (1953) Type 1 analysis of variance was computed using the latency data for the four experimental sessions. This was done employing change scores from the baseline in order to contrast the two groups in terms of gain or loss from the original latency for each subject. Table 5 summarizes this analysis and shows that the difference between groups is not significant at the .05 level. Significant differences are found, however, for the days (.01 level) and for the interaction of days and groups (.001 level). The source of these variations can be seen in Table 4. First of all, the day's effect is reflected in the sharp initial increases in latency for both groups between the baseline day and the first experimental session. The increases are also pronounced for both groups with regard to the final experimental session. The increases over baseline latency for days 3 and 4 are not as great (the experimental group actually drops below the baseline latency on day 3). The days by groups interaction can be seen in Table 4 by the fact that the control group shows the greatest initial increase over baseline latency for the first experimental session and that the increases are never again as great for the subsequent sessions. The experimental group, on the other hand, does not undergo as great as initial increase in latency, actually drops below the baseline on day 3, and then exhibits its highest gain over baseline on day 5.

The 60-second samples were scored for stages of sleep by the same criteria as were the continuous records for the baseline days. The results in terms of numbers of sample recordings of each stage for each experimental session can be seen in Table 3. This table also gives the percentage across days for each stage for each group and from these figures it can be seen that there are some seemingly large differences between groups with regard to Stages 0, III, and IV in particular. It would seem that the experimental group awakens more often, achieves more Stage III and less Stage IV than does the control group. A Chi-square test was employed to test the difference in stage distribution between the two groups using the summed frequencies across all four experimental sessions. Due to the small frequencies for Stages 0 and I, these categories were combined in the statistical test. For the same reason Stage I-REM was omitted. This test was not significant at the .05 level (Chi-square = 5.84 with df = 3).

A further attempt was made to contrast the two groups with regard to the 60-second samples. It will be recalled that the baseline sessions yielded two continuous hours of EEG recordings and that these records when scored for sleep stages varied little from other such groups sampled by other experimenters. The baseline records are employed as an estimate of the "normal" or nonexperimental sleep of the subjects in this experiment. When the mean baseline sleep for the experimental group is compared to that of the control group as is done in Table 6 there seem to be some differences. Separate t-tests were performed contrasting the two groups for each stage of sleep. None of the differences were found to be significant at the .05 level (indeed only one of the t's had a probability of less than .10). The baselines of the two groups, therefore, are not significantly different. Next an attempt was made to contrast a number of the 60-second samples from the experimental sessions with similarly derived samples of the baseline session. This procedure was as follows: It was observed that there were 22 cases in which subjects yielded four or five 60-second sample recordings during one or more of the experimental sessions. There were 12 such cases for the control group and 10 for the experimental group. When the first sample recording for each of the cases of five consecutive recordings was eliminated there were 88 periods which spanned the

TABLE 6

PERCENTAGE OF TIME SPENT IN EACH STAGE FOR BOTH GROUPS DURING THE BASELINE SESSION EMPLOYING FULL RECORDS AFTER THE FIRST EPISODE OF STAGE I

Experimental Group		Control Group	
Stage	Baseline	Stage	Baseline
0	6.41	0	11.40
I	13.45	I	9.29
II	35.68	II	35.68
III	8.45	III	6.33
IV	25.03	IV	11.83
I-REM	10.95	I-REM	15.91
Mean Duration of Record (Minutes)	106.50'	Mean Duration of Record (Minutes)	118.33'

same length of time (40 minutes). All of the periods began between 20 and 25 minutes after the beginning of an experimental session (the mean time of onset for the periods was 22.72 minutes). Since the exact time for each of these 88 sample recordings was known it became possible to return to the baseline record of each subject involved and obtain a similar sample at the same point in that record. There were then 88 samples from the first hour of the baseline data to compare to those from the experimental sessions. This data permits a contrast between the quality of sleep between the experimental sessions (during the first hour when electrical current was being applied) and the baseline during which the subject slept under more customary circumstances.

TABLE 7

NUMBER OF SAMPLE RECORDINGS DURING THE FIRST HOUR CONTRASTING THE TWO GROUPS WITH THE COMBINED BASELINE

Sample	Stages						Sum
	0	I	II	III	IV	I-REM	
Experimental Sessions for Experimental Group	7	4	8	6	15	0	40
Experimental Sessions for Control Group	0	4	20	5	18	1	48
Combined Baseline	9	11	29	8	29	2	88

The data in terms of sleep stages can be seen in Table 7. A Chi-square test was performed to contrast the three sets of sample recordings (experimental, control, and the combined baseline). Once again because of small individual cell frequencies certain categories were combined. Stages 0, I, and II were combined into a category which could be described as "light" sleep while Stages III and IV were combined to represent "deep" sleep. Stage I-REM was such a rare occurrence in the first four that it was eliminated from consideration. The resultant Chi-square value (1.28 with 1 df) fell far short of the .05 level of significance. Thus, when sampled in this manner, the sleep under either form of electrical stimulation does not appear to vary significantly from sleep without electrical stimulation.

Sleep Following Electrical Stimulation

It will be remembered that during the four experimental sessions the electrical stimulation was terminated after one hour and continuous EEG recording was begun. In order to determine whether or not the application of the currents had no effect on subsequent sleep these records were scored for sleep stages and compared to the baseline data. The comparison was made using the second hour of each baseline record and the first hour of continuous record for each experimental session. Thus all records, baseline and experimental, begin after the subject had been in bed for one hour. Table 8 shows this comparison in terms of the percentage of time spent in each stage. The exact number of minutes spent in each stage by each subject can be found in Appendix A. From the baseline column in Table 8 can be seen some seemingly large differences, particularly with regard to Stages 0, II, IV and I-REM. A series of t-tests, however, shows that none of these differences is significant at the .05 level, indeed, only one of the t's (for the Stage IV discrepancy) has a probability of less than .10. These baseline differences such as they are, are shown graphically in Figure 2 and can perhaps be best accounted for in terms of the variation in mean latency between the two groups. As was seen in Table 4, the experimental group took, on the average, 8 minutes longer to achieve the first episode of Stage II in the baseline session and consequently did not have so much time to amass Stage II or to cycle into the deeper stages, particularly Stage I-REM. If Figure 3, which contrasts

TABLE 8*

COMPARISON OF THE FINAL 60 MINUTES OF THE BASELINE DAY TO THE INITIAL 60 MINUTES OF EXPERIMENTAL DAYS

Stage	Days				
	Baseline	2	3	4	5
Experimental Group					
0	4.54	10.00	1.39	1.41	7.22
1	7.34	7.22	2.22	4.51	13.33
II	37.01	32.78	38.61	46.76	37.78
III	7.63	14.17	11.11	7.61	6.67
IV	26.84	18.33	23.89	16.06	17.78
I-REM	16.67	17.50	22.78	23.66	17.22
Control Group					
0	12.18	12.50	1.39	16.94	1.67
1	5.10	16.67	7.22	6.39	8.61
II	46.74	31.67	42.22	32.50	30.28
III	4.82	8.33	8.05	6.39	8.89
IV	5.66	14.17	7.22	21.67	27.78
I-REM	25.50	16.67	33.89	16.11	22.78

*Figures represent percentage of time spent in each stage.

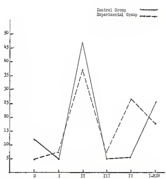

Fig. 2.—Distribution of sleep stages for the two groups during the second 60 minutes of the baseline session.

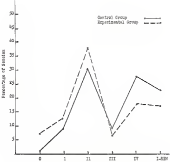

Fig. 3.—Distribution of sleep stages for the two groups during the first 60 minutes of the fourth experimental session (day 5).

the stage percentages for the final experimental sessions, is examined, the discrepancies are seen to decrease. The difference between the two group latencies for that session is only 1.34 minutes. The mean difference for all experimental days is 5.12 minutes and Figure 4 shows that the group differences in terms of stage distribution, when averaged for all four experimental days, all but vanish. By the final experimental session the groups are seen to become more and more alike in terms of latency and stage distribution.

If, for the experimental group, the distribution of the various stages is compared between the baseline session and the final experimental session (see Fig. 5) only a few small differences can be seen. If the same comparison is made for the control group (see Fig. 6) the discrepancies are somewhat larger with the final experimental session characterized most strongly by decreases in Stages 0 and II and increases in Stages III and IV. When similar comparisons are made for each group between the baseline and the mean percentages for the four experimental sessions (see Figs. 7 and 8) the similarities for the experimental group are even more remarkable. For the control group, however, though the general contrast lessens somewhat, the gain across days of Stage IV is still apparent as is the loss of Stage 11.

Six analyses of variance were computed, one for each sleep stage, to contrast the two groups in terms of changes from the baseline session across the four experimental sessions. Once again, a Lindquist (1953) Type 1 design was employed using change scores

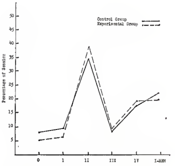

Fig. 4.—Distribution of sleep stages for the two groups for the mean of the first 60 minutes of all four experimental sessions (days 2-5).

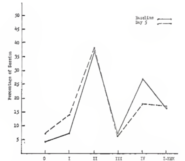

Fig. 5.—Distribution of sleep stages for the experimental group contrasting the first 60 minutes of the baseline session with the second 60 minutes of the fourth experimental session (day 5).

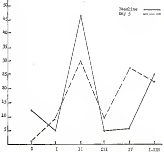

Fig. 6.—Distribution of sleep stages for the control group contrasting the first 60 minutes of the baseline session with the second 60 minutes of the fourth experimental session (day 5).

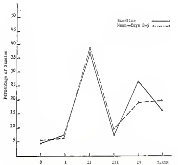

Fig. 7.—Distribution of sleep stages for the experimental group contrasting the first 60 minutes of the baseline session with the mean of the first 60 minutes of all four experimental sessions (days 2-5).

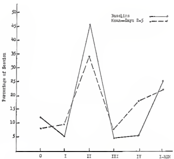

Fig. 8.—Distribution of sleep stages for the control group contrasting the second 60 minutes of the baseline session with the mean of the first 60 minutes of all four experimental sessions (days 2-5).

derived from the number of minutes spent in the given stage during the first hour of an experimental session minus the number of minutes spent in that stage during the second hour of the baseline session.

Table 9 summarizes the analysis of variance for Stage 0. The difference between groups was not significant; neither was the effect of the sessions (days). There was, however, a significant F (.05) for the days by groups interaction which can be seen in Table 8 to be largely attributable to the smaller variability across days by the experimental group.

Table 10 presents the analysis of variance figures for Stage I and shows no significant difference between the groups. There were, however, significant F's for the effect of days (.01) and the days by groups interaction (.001). The effect across days can be seen in Figures 5 and 6 and consists of gains by both groups in Stage I for the final experimental session. The interaction effect appears attributable to the mean loss of Stage I across the four experimental sessions by the experimental group and the mean gain by the control group, as can be seen in Figures 7 and 8.

Stage II presents a similar picture (see Table 11). There is no significant effect between groups but there are significant F's for days (.05) and the interaction of days by groups. The days effect can be seen in Table 8 wherein both groups decrease simultaneously in Stage II percentage when compared to their baselines. The interaction effect can be attributed to the fact that the experimental group shows a slight gain in Stage II in terms of mean percentage across

TABLE 9

SUMMARY OF ANALYSIS OF VARIANCE OF STAGE 0* CONTRASTING THE EXPERIMENTAL AND CONTROL GROUPS ACROSS THE FOUR EXPERIMENTAL SESSIONS IN TERMS OF CHANGE SCORES FROM THE BASELINE**

Source	SS	df	MS	F
Between - Subjects	1775.23	11	161.38	
Groups	82.69	1	82.69	.48
Error (b)	1692.54	10	169.25	
Within - Subjects	2347.75	36	65.22	
Days	259.23	3	86.41	1.74
Days x Groups	601.15	3	200.38	4.04***
Error (w)	1487.37	30	49.58	
Total	4122.98	47		

*As usual, here Stage 0 refers to periods of wakefulness which follow the first recorded minute of Stage II.

**Contrasting the second hour of each baseline record to the first hour of continuous record for each experimental session.

***Significant at .05.

TABLE 10

SUMMARY OF ANALYSIS OF VARIANCE OF STAGE I CONTRASTING THE EXPERIMENTAL AND CONTROL GROUPS ACROSS THE FOUR EXPERIMENTAL SESSIONS IN TERMS OF CHANGE SCORES FROM THE BASELINE*

Source	SS	df	MS	F
Between - Subjects	707.17	11	64.29	
Groups	120.34	1	120.34	2.05
Error (b)	586.83	10	58.68	
Within - Subjects	927.50	36	25.76	
Days	171.17	3	57.06	4.93**
Days x Groups	409.00	3	136.33	11.77***
Error (w)	347.33	30	11.58	
Total	1634.67	47		

*Contrasting the second 60 minutes of each baseline record to the first 60 minutes of continuous record for each experimental session.

**Significant at .01

***Significant at .001.

TABLE 11

SUMMARY OF ANALYSIS OF VARIANCE OF STAGE II CONTRASTING THE EXPERIMENTAL AND CONTROL GROUPS ACROSS THE FOUR EXPERIMENTAL SESSIONS IN TERMS OF CHANGE SCORES FROM THE BASELINE*

Source	SS	df	MS	F
Between - Subjects	7027.33	11	638.88	
Groups	858.52	1	858.52	1.39
Error (b)	6169.21	10	616.92	
Within - Subjects	4074.75	36	113.19	
Days	574.25	3	191.42	3.05**
Days x Groups	1615.50	3	538.50	8.57***
Error (w)	1885.00	30	62.83	
Total	11102.48	47		

*Contrasting the second 60 minutes of each baseline record to the first 60 minutes of continuous record for each experimental session.

**Significant at .05

***Significant at .001

all four experimental sessions while the control group shows a loss (see Figs. 7 and 8).

The analysis of variance for Stage III, as summarized in Table 12, yields no significant F's. Figures 7 and 8 show that both groups make slight gains and that there is little variation across days for this stage.

Stage IV is the only variable for which a significant (.05) difference is found between groups (see Table 13). The control group shows gains over the baseline session for each of the experimental sessions while the experimental group shows consistent losses

TABLE 12

SUMMARY OF ANALYSIS OF VARIANCE OF STAGE III CONTRASTING THE EXPERIMENTAL AND CONTROL GROUPS ACROSS THE FOUR EXPERIMENTAL SESSIONS IN TERMS OF CHANGE SCORES FROM THE BASELINE*

Source	SS	df	MS	F
Between - Subjects	578.17	11	52.56	
Groups	3.00	1	3.00	.05
Error (b)	575.17	10	57.52	
Within - Subjects	740.50	36	20.57	
Days	47.84	3	15.95	.54
Days x Groups	88.00	3	29.33	1.46
Error (w)	604.66	30	20.16	
Total	1318.67	47		

*Contrasting the second 60 minutes of each baseline record to the first 60 minutes of continuous record for each experimental session.

TABLE 13

SUMMARY OF ANALYSIS OF VARIANCE OF STAGE IV CONTRASTING THE EXPERIMENTAL AND CONTROL GROUPS ACROSS THE FOUR EXPERIMENTAL SESSIONS IN TERMS OF CHANGE SCORES FROM THE BASELINE*

Source	SS	df	MS	F
Between - Subjects	4089.17	11	371.74	
Groups	1656.75	1	1656.75	6.81**
Error (b)	2432.42	10	243.24	
Within - Subjects	3092.50	36	85.90	
Days	138.17	3	46.06	1.97
Days x Groups	2251.67	3	750.56	32.05***
Error (w)	702.66	30	23.42	
Total	7181.67	47		

*Contrasting the second 60 minutes of each baseline record to the first 60 minutes of continuous record for each experimental session.

**Significant at .05

***Significant at .001

(see Table 8). The groups by days interaction is also significant which is attributable to the maximum gains by the control group in the last two experimental sessions and the simultaneous maximum losses by the experimental group. The days effect is not significant.

Stage I-REM yielded no significance for any of the effects in the analysis of variance (see Table 14). Figures 7 and 8 show that the experimental group undergoes a slight gain in I-REM across days while the control group undergoes a slight loss.

TABLE 14

SUMMARY OF ANALYSIS OF VARIANCE OF STAGE I-REM CONTRASTING THE EXPERIMENTAL AND CONTROL GROUPS ACROSS THE FOUR EXPERIMENTAL SESSIONS IN TERMS OF CHANGE SCORES FROM THE BASELINE*

Source	SS	df	MS	F
Between - Subjects	1664.73	11	151.34	
Groups	180.19	1	180.19	1.21
Error (b)	1484.54	10	148.45	
Within - Subjects	3998.25	36	111.06	
Days	308.56	3	102.85	1.03
Days x Groups	692.48	3	230.83	2.31
Error (w)	2997.21	30	99.91	
Total	5662.98	47		

*Contrasting the second 60 minutes of each baseline record to the first 60 minutes of continuous record for each experimental session.

The two groups were also compared in terms of the number of stage changes per session employing the same time intervals as were used in the preceding analyses of stage distribution. For each session, baseline through the final experimental session, a count was made of the number of times each subject changed from one stage of sleep to another. Change scores were computed by subtracting the number of changes in each experimental session from those in the baseline session. Table 15 gives the number of changes for both groups across all sessions and shows that both the difference between groups and between sessions are small. The mean in minutes per stage episode estimates the average time spent between changes. Once again, a Lindquist (1953) Type I analysis of variance was computed. The analysis yielded no significant effects (see Table 16).

One further consideration was given which involved these same post-stimulation sessions. This was the length of time between the onset of the first minute of Stage II (or the second consecutive failure to respond to the signal tone) and the first occurrence of one of the "deeper" stages, III, or I-REM. This includes, of course, the time actually spent in the first episode of Stage II. This consideration necessarily involves the use of sample readings during stimulation in those cases where sleep first occurred during the first hour of an experimental session. From Table 17 it can be seen that for both groups transition from Stage II to one of the deeper stages took longer during the first experimental session than during any other session. A t-test shows that the difference between the baseline data for the two groups is not significant. Again a Lindquist (1953) Type I analysis of variance was employed using change scores from the baseline and contrasting the two groups across the four experimental sessions. Table 18 presents the analysis of variance summary and shows no significant differences for any of the effects. Apparently the transition from Stage II to "deeper" stages is neither significantly prolonged nor speeded by either form of electrical stimulation.

Another observation should be mentioned. In most cases (136 out of 147 sample recordings), termination of either form of current did not awaken the subjects. Looking once more at Table 7, it can be seen that when both the baseline and experimental sessions are sampled there are actually two more instances of Stage 0 in the baseline samplings.

TABLE 15

STAGE CHANGES FOR BOTH GROUPS FOR ALL FIVE DAYS

Subject	Days									
	Baseline		2		3		4		5	
	Changes	Minutes	Changes	Minutes	Changes	Minutes	Changes	Minutes	Changes	Minutes
Experimental Group										
1	14	91	9	98	5	70	16	93	14	89
2	13	99	12	100	10	84	5	84	10	90
3	12	89	12	100	10	94	5	86	9	88
4	12	120	14	96	8	83	7	55	15	97
5	19	120	18	81	12	73	16	69	26	119
6	18	120	8	80	10	73	17	77	10	67
Sum	88	639	73	555	55	477	66	464	84	550
Mean Length per Stage Episode		7.26'		7.60'		8.67'		7.03'		6.55'
Control Group										
7	19	120	7	120	10	80	6	92	25	79
8	31	120	24	88	16	88	15	81	7	77
9	9	120	9	110	5	118	7	75	9	86
10	8	117	11	103	12	113	14	76	13	112
11	18	113	18	88	24	76	11	73	20	85
12	13	120	13	77	8	76	9	60	9	120
Sum	98	710	82	586	75	551	62	457	83	559
Mean Length per Stage Episode		7.24'		7.15'		7.35'		7.37'		6.73'

TABLE 16

SUMMARY ANALYSIS OF VARIANCE OF STAGE CHANGES CONTRASTING THE EXPERIMENTAL AND CONTROL GROUPS ACROSS THE FOUR EXPERIMENTAL SESSIONS IN TERMS OF CHANGE SCORES FROM THE BASELINE*

Source	SS	df	MS	F
Between - Subjects	652.73	11	59.34	
Groups	2.52	1	2.52	.04 NS
Error (b)	650.21	10	65.02	
Within - Subjects	253.25	36	7.04	
Days	27.23	3	9.08	1.51 NS
Days x Groups	45.15	3	15.05	2.50 NS
Error (w)	180.87	30	6.03	
Total	905.98	47		

*Contrasting the second 60 minutes of each baseline record to the first 60 minutes of continuous record for each experimental session.

TABLE 17

LATENCY FROM THE FIRST MINUTE OF STAGE II UNTIL THE FIRST MINUTE OF STAGE III, IV OR 1-REM

Subject	Days				
	Baseline	2	3	4	5
Experimental Group					
1	3	42	40	10	20
2	18	10	25	10	40
3	18	28	31	10	20
4	10	10	0	0	10
5	11	10	0	10	9
6	17	35	0	46	10
Sum	77	135	96	86	109
Mean	12.83	22.50	16.00	14.33	18.17
Control Group					
7	25	37	20	20	10
8	19	7	32	10	10
9	21	10	10	0	10
10	17	0	0	15	15
11	0	25	16	36	4
12	17	54	21	0	14
Sum	99	133	99	81	63
Mean	16.50	22.17	16.50	13.50	10.50

TABLE 18

SUMMARY OF ANALYSIS OF VARIANCE OF THE LATENCY FROM STAGE II TO STAGE III, IV OR 1-REM IN TERMS OF CHANGE SCORES FROM THE BASELINE*

Source	SS	df	MS	F
Between - Subjects	5657.92	11	514.36	
Groups	397.50	1	397.50	.76
Error (b)	5260.42	10	526.42	
Within - Subjects	6358.00	36	176.61	
Days	543.42	3	181.14	1.14
Days x Groups	1067.59	3	355.86	2.25
Error (w)	4746.99	30	158.23	
Total	12015.92	47		

*Contrasting the second 60 minutes of each baseline record to the first 60 minutes of continuous record for each experimental session.

CHAPTER V

DISCUSSION

Gilyarovskiy and his associates (1958) have made many statements regarding the therapeutic value and essential uniqueness of the sleep which is induced by the cranial application of certain current parameters. These researchers have clearly indicated that sleep which accompanies and follows such stimulation has a different quality and effect than the sleep which a human subject might normally experience by simply lying down in a quiet and comfortable place and waiting. They also make it clear that major deviations, even in the method of cranial application should result in failure to induce the special state called electrosleep. The present investigator has taken great care to employ current parameters in the proper range and to apply these to the subjects of the experimental group in a manner identical to that of previous electrosleep researchers. Since the control group received electrical stimulation at a point quite distal to the head, differences between the groups might logically be expected to occur if the sample of subjects was not deviant and if the two contrasted groups did not show any significant initial (baseline) differences. From Chapter II it is clear that the various proponents of electrosleep are not specific in indicating what differences in terms of sleep parameters are to be expected. For this reason a broad range of sleep parameters was studied in an attempt to determine which might be relevant.

The Baseline Sleep of the Present Sample

The distribution of the various sleep stages for all of the subjects in this experiment was compared to that of the subjects of two normative studies of the afternoon sleep of young adults (Webb and Agnew, 1967; Maron, *et al.*, 1964). The three sets of data matched closely. The present sample does not appear grossly deviant with regard to stage distribution.

When the baseline data for the experimental group was compared to that of the control group no statistically significant differences were found between the two groups with regard to the following variables: sleep latency, stage distribution, mean duration of stage episodes, and the length of time between the first onset of Stage II and the first onset of one of the "deeper" stages. The two groups do not deviate from each other initially to any statistically significant extent on any of the variables studied.

Sleep Samples During Electrical Stimulation

The one-minute sample recordings taken at 10 minute intervals provided the most direct estimate of electrosleep parameters and yet no statistically significant differences could be demonstrated either by contrasting the two complete sets of sample recordings directly or by contrasting both with samples taken from the same minutes of the baseline sessions. It must be borne in mind, however, that several factors reduce the usefulness of the approach. It will be recalled that the minimum obtainable latency for any subject in an experimental session was approximately 15 minutes and that the consequent maximum number of one-minute samples was five. Even under optimum circumstances there were in the first hour of every experimental session, 15 minutes from which no sample was obtained and of the remaining 45 minutes, the stage quality could be determined for only five. In addition to this the discontinuous nature of the data obtained by the sampling method forced the investigator to use less sensitive nonparametric statistical tests. Even though the differences failed to achieve significance it was noted that the one-minute sample records of the experimental group showed a greater proportion of Stage 0 and a smaller proportion of Stage IV than did those of the control group. It will be shown below that this same relationship appears in the subsequent continuous recordings for experimental sessions.

Among the sample recordings there were six instances in which the first one-minute sample was scored as Stage 0. This is remarkable in that the first samples were taken within two or three seconds of the subject's second consecutive failure to respond to the signal tone. Luce (1965), in an extensive review of the relevant literature makes it clear that a subject who is experiencing either Stage 0 or I is under ordinary circumstances capable of hearing and responding to a signal tone such as the one employed in this study. The same author indicates that for a subject in Stage II or one of the "deeper" stages there is little probability of a response to such a tone. It was assumed, therefore, that a subject, if he was willing to make such a response (as was every subject in the present study on one or more occasions), would do so unless he was experiencing Stage II or a "deeper" stage. One hypothesis that could account for these initial recordings of Stage 0 has been considered. If the subject were in Stage II at the time of both signal tones, these tones followed by the cessation of electrical stimulation may have provided a combination of stimuli sufficient to evoke arousal.

In terms of sleep latency the groups were more alike in the experimental sessions than they were on the baseline day. The mean baseline latency for the control group was shorter than that of the experimental group. Across the experimental sessions both groups did tend to increase in latency and in every case but day 3 the experimental group had the shorter latencies. Each group varied differently across days and this resulted in a significant interaction effect. There was also a significant effect for days (sessions). This obviously resulted from the longer latencies shown by both groups in the first and last experimental sessions (days 2 and 5). The longer latencies in the first experimental session might be interpreted as the result of the novelty and perhaps discomfort of the electrical stimulation. The novelty of the introduction of the signal tone might also have contributed to longer latencies on this day. These factors would not account, however, for the recurrence of longer latencies on the fifth day. The author can offer no reasonable explanation for this except to note that one subject (see Table 4) contributed disproportionately to increased latency of the experimental group on day 5. The group differences in sleep latency were not found to be significant for either the baseline or the experimental sessions. Obviously, neither the cranial stimulation nor the leg stimulation resulted in a decrease in latency. It should be noted, however, that because of the minimum possible latency (15 minutes) imposed by the signal-response criterion some individual baseline latencies were not free to vary in the negative direction. There were three subjects in each group with baseline latencies shorter than 15 minutes. This would make it more difficult for a decreasing trend to reveal itself.

Sleep Following Electrical Stimulation

The experimental and control groups did not differ significantly in terms of stage distribution when the second hours of their baselines were compared. Moreover it was noted that even the nonsignificant differences between the groups decreased when they were compared across all four experimental sessions. Across the experimental sessions the control group shows the greater degree of variability for all stages except I. The control group showed greater changes in relation to the baseline. The direction of these changes on the part of the control group was such as to decrease the between groups differences. This factor made a major contribution to the four significant groups by days interactions particularly those for Stages 0, II and IV. The other significant interaction from the analysis for Stage I was influenced by the fact that both groups showed small but consistent changes across the four sessions in opposite directions. The experimental group decreased in Stage I while the control group increased.

The greatest single contribution to the greater variability of the control group was the tendency to increase consistently across days in Stage IV percentage. This tendency increased the largest overall difference between the groups but provides, in terms of change from the baseline, the only significant difference between the groups. The control group variance is also seen as the major component of the significant days effect for Stage II. The experimental group varies in the same direction but to a much smaller extent.

From the above discussion it can be seen that the changes exhibited by the control group account for the tendency seen in Figure 4 for the two groups to become more similar when compared across the four experimental sessions. These changes consist mainly of increases in Stage IV and decreases in Stage II. There was also a tendency for the control group to exhibit decreases in Stage 0 during the sessions. The experimental group exhibited gains in Stage 0. Though these Stage 0 changes are not significant they are mentioned because of the previously noted trend in the same direction found in the sampling data. Across experimental sessions the experimental group exhibited slight but consistent decreases in Stage IV. There was also less Stage IV exhibited in the sample recordings of the experimental group than in those of the control group.

Two other variables were studied. These were the number of stage changes and the latency between the first occurrence of Stage II and the first occurrence of one of the "deeper" stages. Little variation could be seen either between or within groups in either variable.

Both measures remained stable across experimental sessions and no significant effects were found in either analysis of variance. Both the experimental and control groups tended to take longer to reach one of the "deeper" stages in the first experimental session than in any other session. This could perhaps be accounted for in terms of the novelty of the experimental session as was mentioned in connection with the latency data.

In summary there were few apparent differences between the two groups. The only significant difference between groups was for Stage IV and this was due mainly to increases across the experimental sessions by the control group. The experimental group varied less across experimental sessions tending to decrease slightly in Stage IV. There was also a nonsignificant tendency for the experimental group to exhibit more Stage 0 after sleep onset in both the first and second hours of the experimental sessions. The experimental group also varied less across sessions in relation to its own baseline than did the control group. It is concluded that in general the effect of cranial stimulation on the various sleep parameters studied is not as great as is the effect of applying similar currents to the leg. This is particularly apparent when changes from the baseline are considered. Insofar as there were differences resulting from the two methods of current application these took the form of less Stage IV for the experimental (cranial application) group. There was also a nonsignificant tendency for the same group to experience more Stage 0. These same factors are seen both during and after stimulation. It cannot be said from these findings that standard application of electrosleep currents results in "deeper" sleep; a tendency to the contrary is apparent. It cannot be said that as a sleep induction technique this method shortens latency. It should be noted that proponents of the use of this technique, e.g., Gilyarovskiy, et al. (1958) have not made clear claims that the device would produce shorter latencies; neither have they referred to the subsequent sleep as "deeper" in the sense in which it is used here. For this reason the data in the present study should not be interpreted to say that there is no electrosleep effect or that the effect is slight. If the effect does exist, it could show itself in terms of other variables beyond the scope of this study.

CHAPTER VI

SUMMARY

An experiment was conducted to determine various psychophysiological parameters of sleep during and after the cranial application of certain electrical currents. The parameters of these currents were within the range of those used in the technique which has been referred to as electrosleep. The pulse generator (electrosleep machine) employed was built at the University of Florida to conform to the output characteristics of those used in previous studies.

Subjects were male university students who ranged in age from 18 to 25 years. They were assigned to two equal groups (experimental and control) which were balanced for sleep latency. Subjects were studied in pairs for five consecutive days during the afternoon. They reclined on comfortable beds in a well-equipped sleep laboratory. Each was told that it was permissible for him to sleep if he chose. On the first or baseline day each subject slept for approximately two hours during which EEG and EOG recordings were made. On subsequent days the subjects in the experimental group were stimulated cranially in the standard manner with electrosleep currents for one hour. The control group had similar currents applied to the leg for one hour. If, during the course of this hour, a subject fell asleep (as determined by failure to respond to a signal tone presented at predetermined intervals) the pulse generator was turned off and a one-minute sample

EEG-EOG record was made. Once the recording was made electrical stimulation was resumed. Subsequent recordings were made at predetermined intervals until the end of the hour at which time continuous EEG-EOG recordings were made until the subject had slept for two hours.

The records were scored for stages of sleep using a modification of the system of Dement and Kleitman. The baseline sleep of the combined groups was compared to that of the subjects of two normative studies in terms of sleep stage distribution. All three samples were similar. The one-minute sample recordings for the two groups were compared both to each other and to samples taken from the identical time intervals of the baseline records. The bases of comparison were distribution of sleep stages and sleep latency. No statistically significant differences were found between the two groups. A tendency was noted for the experimental group to awaken more often during the first hour than did the control group.

The records of sleep following stimulation were also compared in terms of stage distribution, the number of stage changes, and the latency from Stage II to the first "deeper" stage. Analyses of variance (using change scores from the baseline) yielded no significant differences for these last two variables. The groups differed significantly with regard to only one variable, percentage of Stage IV. There was also a significant tendency for the latencies of both groups to vary across experimental sessions. A nonsignificant tendency was noted for the experimental group to spend more time in

Stage 0 (wakefulness). Both across experimental sessions and between the baseline and experimental sessions the control group showed a greater tendency to change with regard to sleep patterns than did the experimental group.

In general it was found that the experimental group varied only slightly from its own baseline parameters. It can be said that the experimental group differed significantly with regard to a tendency to experience progressively less Stage IV across experimental sessions. This was considered in combination with the nonsignificant tendency for this group to spend more time in Stage 0 in both the first and second hours of experimental sessions. It was concluded that electrosleep was neither deeper nor more rapid in onset than either nonexperimental (baseline) sleep or the sleep of subjects who received electrical stimulation on the leg.

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APPENDIX A

MINUTES IN EACH STAGE FOR EACH SUBJECT ALL 5 DAYS

Subject	Stages												Subject
	Experimental Group						Control Group						
	0	I	II	III	IV	1-REM	0	I	II	III	IV	I-REM	
Baseline													
1	0	3	11	6	0	34	1	8	36	8	7	0	7
2	2	6	34	1	8	8	1	3	33	7	0	16	8
3	1	5	24	7	23	0	39	1	5	0	0	15	9
4	13	12	20	0	8	7	2	4	21	0	0	31	10
5	0	0	17	5	34	6	0	1	32	1	5	16	11
6	0	0	24	8	22	4	0	1	38	1	8	12	12
Sum	16	26	131	27	95	59	43	18	165	17	20	90	
Day 2													
1	0	3	24	6	6	63	0	26	25	4	5	0	7
2	0	2	32	9	12	5	1	4	26	6	6	17	8
3	35	6	9	7	3	0	29	14	13	4	0	0	9
4	1	14	6	11	18	10	0	6	12	6	9	27	10
5	0	0	25	15	14	6	0	4	21	6	13	16	11
6	0	1	22	3	13	21	15	6	17	4	18	0	12
Sum	36	26	118	51	66	63	45	60	114	30	51	60	
Day 3													
1	0	0	15	8	0	37	0	4	21	6	13	16	7
2	0	2	14	4	33	7	0	3	16	0	0	41	8
3	0	0	19	18	20	3	2	9	39	9	1	0	9
4	0	0	46	0	0	14	0	2	42	10	0	6	10
5	5	4	15	5	21	10	0	2	13	0	12	33	11
6	0	2	30	5	12	11	3	6	21	4	0	26	12
Sum	5	8	139	40	86	82	5	26	152	29	26	122	

Day 4													
1	0	2	27	0	0	31	0	10	27	2	18	3	7
2	0	2	22	3	8	25	0	1	20	7	17	15	8
3	0	3	7	0	32	18	44	3	1	0	0	12	9
4	0	2	47	6	0	0	3	2	39	5	6	5	10
5	0	3	40	5	2	10	0	0	16	3	18	23	11
6	5	4	23	13	15	0	14	7	14	6	19	0	12
Sum	5	16	166	27	57	84	61	23	117	23	78	58	
Day 5													
1	0	4	14	4	3	35	0	4	26	0	24	6	7
2	0	4	38	3	15	0	0	1	2	15	42	0	8
3	9	9	11	0	17	14	6	5	30	7	6	6	9
4	0	9	29	7	2	13	0	0	15	2	0	43	10
5	2	3	18	10	27	0	0	13	15	1	16	15	11
6	15	19	26	0	0	0	0	8	21	7	12	12	12
Sum	26	48	136	24	64	62	6	31	109	32	100	82	

APPENDIX B

STAGE QUALITY OF THE SAMPLE RECORDINGS[a] FOR EACH SUBJECT DURING THE FIRST HOUR OF EACH EXPERIMENTAL SESSION

	Days								
	Experimental Group					Control Group			
	2	3	4	5		2	3	4	5
Subject I	I II II *	0 0 II II III	II III IV *	II II III *	Subject 7	**	II I II II	II III I *	II IV IV IV
Subject 2	II III *	II II II	II III II	II II II	Subject 8	II IV IV II	II III IV IV	IV IV IV III	II III IV I-REM
Subject 3	II II *	II II *	II III IV	0 II III	Subject 9	0 *	**	IV IV II II I	IV II I II *
Subject 4	II III IV *	III IV IV I I-REM	III IV IV II I	II III *	Subject IO	II II *	**	II II II	**

Subject 5	II III IV IV *	III III IV 0 I	II III IV IV IV	II	Subject 11	0 II II *	I II III IV	II II III II	II IV IV IV
Subject 6	0 II II II *	III IV IV IV *	0 0 0 0 *	II III II IV IV	Subject 12	IV IV I	IV IV II II II	**	**

[a] Sample recordings for each day are presented in the order of occurrence.

*No further recordings on this day.

**Subject did not reach sleep criterion on this day.

BIOGRAPHICAL SKETCH

William Edgar Boblitt was born in Springfield, Ohio, on August 27, 1935. He was graduated from Cheyenne High School in Cheyenne, Wyoming, in June of 1953. In the Fall of that year he enrolled at the University of Wyoming which he attended for two years. He then spent five years as an employee of the Glenn L. Martin Company of Denver, Colorado.

In the Spring of 1960, he enrolled at the University of Denver from which he was graduated in June, 1962, with a Bachelor of Arts degree in psychology. Then he entered the University of Florida for graduate studies in psychology and received the Master of Arts degree in June of 1965. From September, 1965, to the present he has been pursuing work toward the degree of Doctor of Philosophy. In 1962 he was awarded a United States Public Health Service Fellowship which he held for two years. In 1964, he was a Veteran's Administration Trainee. In 1965, he was awarded a Georgia Public Health stipend which he still holds. He has served a twelve-month internship in clinical psychology at Milledgeville State Hospital, Milledgeville, Georgia.

William Edgar Boblitt is married to the former Sharon Anna Moore. He is a member of Psi Chi, the Southeastern Psychological Association, and the Georgia Public Health Association.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Arts and Sciences and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1967

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